From the history of the M-21 field jet system

S.V.Gurov

Work on the system began in the second half of the 50s. According to the plan of development works for 1959, approved by the Minister of Defense and agreed with the GKOT, the head executor of the whole "Grad" theme was NII-24, to which, as well as to the Technical Department of GKOT by letter № 597979 of February 7, 1959 was sent a draft of tactical and technical requirements for this work for approval. On March 12, 1959 there were approved "Tactical and technical requirements for the development work No.007738 "Division field jet system "Grad" /to the I department I of ASTC GAU/ (Artillery Scientific and Technical Committee of the Main Artillery Department). In the GAU archive data for 1959, the system is mentioned as a divisional field system "Grad". According to this plan, NII-147 GKOT was the executor only on the rocket engine. However, at the end of the first half of February 1959 correspondence indicated that the NII-147 was the developer of an uncontrollable rocket to the "Grad" system. Letter No. 01844 of 18 April 1959, Deputy Director for Research at the NII-147 A. N. Ganichev (signed by another person) appealed to the head of the 1st Main Directorate of Artillery Scientific-Technical Committee, Major-General MK Sokolov, with a request to give permission to familiarize representatives of SRI-147 with the data of the shell "Strizh" in connection with the development of the shell to the system "Grad". In response to this letter the Deputy Head of the I Department of ASTC Colonel Pinchuk sent a letter to the Director of NII-147 GKOT t.Khristoforov, in which it was reported about temporary use of the report on tests of projectile R-115 and drawings on the engine body of this projectile, for the use of these materials in the development of the projectile to the "Grad" system. It was necessary to return the materials to the I-st Department of ASTC GAU before August 15, 1959.

From the explanatory note on the sketches of missile projectiles became known about the versions of projectiles with a combined jet engine /start engine - powder, marching engine - direct-flow air jet on solid fuel/.

1. Rocket projectiles with combined engine of 122 mm caliber, designed for manufacturing and testing by firing prototypes of 25 pieces each of 2 versions.

Option 1. Its main data are as follows:

Weight of the final projectile	73 kg
Weight of combat unit	16 kg
Weight of powder draughts of the starting engine (powder RSI-12M)	20 kg
Solid fuel weight of the marshal engine	3 kg
Start engine running time	1,5-3 sec
Operating time of the marshal engine	13 sec

The projectile consisted of a combat unit, a gunpowder starting engine and a solid fuel marching SARD in the form of four gondolas with air intakes, reinforced independently in the tail unit. The starting engine carrying case consisted of two stamped cylinders. The bottom of the upper cylinder served simultaneously as the bottom of the rigged head. The straight-flow engine gondolas, located at an angle of 1° and the projectile axis, when burning solid fuel draughts in them, in a certain range of flight speeds, developed thrust, providing the projectile with an increase in range, while communicating the rotation relative to the axis.

The starting engine and the marching engine were activated simultaneously and after 2 seconds, when the required flight speed was reached, the marching engine went into operation.

Described above version of the RS with combined engine provided for the use of powder rocket developed by NII-147, as a launch accelerator. The role of stabilizers was performed by straight-flow engine gondolas.

Option No. 2. Its basic data are as follows:

Weight of the final projectile	75 kg
Weight of combat unit	16 kg

Weight of powder draughts of the starting engine (powder RSI-12M)	20 kg
Solid fuel weight of the marshal engine	4 kg
Start engine running time	1,5 – 3 sec
Operating time of the marshal engine	13 sec

The rocket projectile of option II had the same principal design scheme as option I. The difference is that the solid propellant of the marching engine was concentrated in one central compartment in the form of two cylinders, and in case of incomplete combustion its products flowed out through four holes in the gondolas, where their complete combustion in the air stream took place.

The marching engine was attached to the powder rocket NII-147 through an adapter, which was screwed in place of the nozzle block of the rocket. Powder gases of the launch engine were led through the central tube for the marching engine.

Solid propellant ignition of the marshal engine came from powder gases of the launch engine, which passed through special small holes in the central tube.

II. Preliminary design of a rocket projectile with a combined engine of 140 mm caliber.

Plan of work on the topic № KNZ-001-59, providing for the cooperation of a number of enterprises during the development of powder rocket in NII-147 and the marching engine prefix in NII-24, was due to tight deadlines /beginning of the 1st quarter, the end of the 3rd quarter of 1959 / on its implementation.

As a result of preliminary conceptual study it was revealed that the selected caliber of 122 mm powder engine projectile allows the closest approach to the execution of the TTT points in terms of total number of projectiles on the launcher and achieving the maximum range of fire at a given RS weight.

Performance of the TTT point on achievement of the maximum firing range could be considerably facilitated with the use of the SARD on solid fuel. However, in order to perform the TTT by weight of the final projectile, it would be more reasonable to switch to the 140 mm caliber for combined engines.

It was considered that the developed conceptual design /variant III/ of 140 mm rocket projectile with combined engine using the experimental material accumulated during the development of 122 mm RS of variants I and II would allow to choose the required design solution of the divisional field rocket system providing the performance of the TTT, and for the maximum range of fire their significant excess.

The RS design of III variants essentially repeated the variants I and II, with respect to Go/Sk, where Go is the weight of the final projectile, and Sk is the passive weight of the projectile, which is more favorable.

The main data of variant III are as follows:

Weight of the final projectile	61,7 kg
Weight of combat unit	17 kg
Weight of starting engine gunpowder checkers	17,2 kg
Solid fuel weight of the marshal engine	7 kg
Start engine running time	1,5 – 3 sec
Operating time of the marshal engine	12 sec
Approximate /calculation/ range of fire at an elevation angle of 50°	25000-30000

With further design work, there is reason to expect that the weight of the missile will be reduced to 55 ¸ 56 kg.

As a result of consideration of letter NII-24 GKOT No. 03028/156 of July 4, 1959 on the direction of development of the conceptual design of the projectile to the system "Grad", the 1st Department of ASTC GAU noted the following:

The development of the projectile was carried out in two directions:

- with a combined engine, which was a combination of a conventional powder start engine developed by NII-147 and 4 solid fuel SARD marching engines. The projectile weighed 72-76 kg

and had a range of about 35 km.

- with a pure powder ordinary jet engine. Designed by NII-147 GKOT. The projectile weight of this variant was equal to about 60 kg and flight range - about 20 km.

During the discussion at the ASTC of GAU on July 16, 1959, the use of the I direction /SWAP on solid fuel/ with regard to the projectile was considered complex and heavy.

However, taking into account that the work on the projectile to the "Grad" system was carried out as a sketch design, the 1st Directorate of the ASTC of GAU did not object to the experimental verification of this projectile in the amount of 30 shots.

The projectile of the second variant was more acceptable from the point of view of weight and production data for the divisional system, but it should be noted that the necessity of using thermal insulating coating in it cannot be considered justified from the point of view of firing safety, taking into account mass production, conditions of transportation and storage of these projectiles. As experience with other products has shown, the application of thermal insulation coating was a laborious and complicated operation. In addition, reliable methods of quality control of the coatings were not developed.

That is why the 1st Department of ASTC of GAU found it expedient to check the variant of projectile with jet engine without thermal insulation coating during further development of projectile to "Grad" system.

From October, 7th till October, 9th, 1959 on Pavlograd range SKB-10 firing tests of 122 mm of uncontrollable projectiles of the drawing ¹ 693-968-7 with the marching air jet engine on solid fuel of the drawing ¹ 6345 with additions ¹ 1971-59g, ¹2008-59 have been carried out. The tests were conducted according to the NII-24 program for the outgoing one No 04152/156 dated September 21, 1959 and amendments made to the program by the representative of NII-24. The tests were attended by: from NII-24 - A.V. Kozlov and N.V. Gavrilin; from NII-147 V.N. Markin, G.A. Denezhkin, A.I. Saveliev; from SKB-203, L.V. Prokhorov. From report No. 057 on the firing test of 122 mm unguided rockets in drawing No. 693-968-7 with a solid-fueled direct-flow air jet engine, drawing No. 6345 with additions No. 1971-59, No. 2008-59 Inventory No. 2. No. 18317 (the report was signed by Chief Designer of the SKB-10 Kurilenko, Head of the Test Department Vasilyev and Head of Experimental Design Ryabov; the report was coordinated with the senior military adviser of the UZIP SAT of the Air Force, Colonel Voronentsev; it was printed on November 10, 1959), it became known about the works on 122 mm calibre rockets:

The purpose of the tests:

1. Check the functioning of the solid fuel marshalling direct-flow air jet engine;
2. To check the strength of the developed design of the marshal engine and its components;
3. Determine the external ballistic characteristics of 122 mm RS with airborne SAW;
4. Determine the range and heap of combat.

Test results

The tests were started on October 7, 1959 to check the projectiles and the correctness of flight at an elevation angle of 20°, while taking photographs of SCS-I and KS-50. Three shots were fired:

- I projectile fell at a range of 8030 m. Marshal's engine without fuel.
- 2 projectiles fell at a range of 7880 m. The marching engine with inert checkers.
- 3 rounds fell at a range of 9440 m. Marshal's engine with fuel.

The shells started off normally.

On October 9, 1959, tests were carried out to check the performance of the 2-variant cones (see photo of one of the variants of the projectile with cones). Diffuser details No. 7B and 9B were shot 4 times (3,4,5 and 6 rounds) and Diffuser details No. 7 and 9 in drawing No. 1971-59 were shot 3 times (1,2,7 rounds). Shots were fired at 20º elevation angle.

SKS-I and KS-50 were photographed. The gunpowder composition ejection from the marching engine in the active part of the trajectory was seen in 5 samples. No ejections were observed on 5 and 6 samples. The first projectile fall was not noticed, it came to the area of 8 km by the sound.

- 2 shells fell at a distance of 7850 m.
- 7 shell fell at a distance of 8100 m.

with 7V and 9V cones

- 3 rounds fell at a distance of 8180 m.
- 4 rounds fell at a distance of 7,770 m.
- 5 shells fell at a distance of 9050 m.
- 6 rounds fell at a distance of 8650 m.

Tests have been suspended according to the telegram NII-24 for № 725 from October 17, 1959.

From the report ¹050 on firing test of 122 mm rockets of drawings ¹ 693-968-7 and 695-970-7, design and manufacturing of Research Institute-147, it became known the following:

From September 7 to October 23, 1959 in Pavlograd SKB-10 the mentioned projectiles were tested. The tests were carried out according to the NII-147 program, the revised program, as well as changes made to the program by a representative of NII-147 during the tests.

They were present during the tests:

- from NII-147 t.t. Maryin V.N., Ganichev A.N., Lebedev K.I., Dmitriev V.I., Markin V.N., Gorlachev P.M., Denezhkin G.A., Saveliev A.I., Cheremukhin R.G., Tolpakin N.V., Ivanovsky O.G., Streis A.N., Makarkin V.N. and others.
- from NII-24 - t.t. Kozlov A.V., Gavrilin N.V.
- from NII-6 - t. Volodkin A.Y.
- from SKB-203 - t. V.M. Prosselov, L.V. Prokhorov.
- from SSCB-604 t.Korneev I.V., Gavrilin N.V. from NII-6 - t.Volodkina A.Ya.
- T.M.C. t. Demin V.S.

A total of 74 shots were fired, of which: 7 rounds were heated at +50°C for 63 hours and 7 rounds were cooled at -40°C for 56 hours (with interruptions of about 3 hours).

56 shots were tested for accuracy (8 groups of 7 shots per group) and 18 shots were fired for correct flight of shells.

Targets of the test

Checking the strength, range, blast and fragmentation of the projectile, the heap of battle, equipment durability and development of elements of the launcher guides to check the sketch design.

For the tests, two versions of the projectile are presented - a hard plumage version (see photo) and a swinging plumage version;

The following launchers were used: a single barrel rigid stabilizer test rig mounted on a concrete foundation (see photos 1 and 2) and the same rig, but with a removable sliding stabilizer test guide.

Prior to the revised programme, preliminary tests were carried out under programme No. 03543 to verify that the projectile had flown correctly and to determine its range, with 12 hard stabilizer pcs. and 3 opening stabilizer pcs. tested.

Of the 12 hard stabilizer pcs, three rounds were fired at an elevation angle of 10º and nine rounds at an elevation angle of 50º. The rate of descent was determined by means of SCS-I.

When testing the projectiles with rigid stabilizer at the first shot on the initial section of the trajectory the head chamber was torn to pieces, which fell in the area of 50-100 m from the guide. Most of it was found at 400 m from the guide rail and the tail chamber with stabilizer at 100 m from the installation. Part of the head gunpowder was burnt out on the ground at a distance of 120 m from the installation, the tail gunpowder pieces with a small splinter were found at a distance of 100 m from the installation.

The second projectile started normally (made at an elevation angle of 10º) and was found at a distance of 10600m. The projectile was dug out. September 8, 1959. Three shots were fired. The first was fired at an elevation angle of 10º and two at an elevation angle of 50º.

The first was found at a distance of 10,500 m. The first shot was fired at an elevation of 10º and two at an elevation of 50º. The second came at 22-23 km (not found), the third was found at 22700m. All three shells started normally. On September 9 and 10, the projectiles were tested in drawing No. 695-970-7 with a retractable stabilizer

drawing No. 695-970-7 with a retractable stabilizer.

Two shots were fired at an elevation angle of 10º, their drop was found at 10,100 and 9600 m, and one at an elevation angle of 50º, the drop was found at 2,500 m.

On September 10, 1959, heap tests were conducted, 7 shots were fired at an elevation angle of 50º. All visual observation shells started normally. The start of the first five was photographed by SCS-1.

During the fire test, the vibration parameters of the launcher were measured (see photo) at the moment the projectile descended.

Inductive sensors with a moving core inside the sensor coil were used to determine the vibration parameters of the launcher at the time of projectile descent. The rod with the core was attached directly to the launcher frame of the launcher, and the sensor coil was rigidly attached to a fixed, rigid support. The latter was a welded tripod from channel 20, at the end of which, a corner for mounting the sensor coil was attached. The coil was connected to a bridge phase sensitive rectification scheme, from which the signal of electrical recording of the amplitude of oscillation of the starting installation was fed to the oscilloscope loop. The sensor coil was powered by a 3G-10 sound generator.

It was not possible to record the installation's oscillations in the horizontal plane.

The conclusions indicated the following:

1. When tested by firing projectiles with plastic intermediate, tail apertures and grids, two premature ruptures of jet chambers at the initial section of the trajectory were obtained. When these parts were replaced by steel, there were no premature ruptures.
2. In the heap test, the best results were obtained in the group with a seven-nozzle block (WD/X = 1/136 and WB/X = 1/333). In the group with a retractable stabilizer, the heap test result is unsatisfactory in terms of probable dispersion over the range of W/X = 1/74. At the location of the locking device at a distance of 1640 mm from the rear cut of the guide the following results on the heap of combat are obtained: WD-X = 1/72 and WB-X = 1/140.
3. There were no failures in operation of the B-613 fuses. In the drawing of Inventory 10966, the general view of the fuse size Ø50C5 is not consistent with the size of the goggle for the fuse of the projectile combat unit, as a result of which when the fuse is screwed into the combat unit of the projectile, the yield is equal to 7 mm.

The range of projectiles with steel diaphragms and lattice at normal charge temperature is 23370 m, at +50°C - 24246 m and at charge temperature -40°C - 22267 m.

From the letter of the military foreman of the GAU ¹148 at SKB-203 major engineer Renzin to Vrid Head of the 5th Department of the ASTC of GAU Colonel Pinchuk Yu.T. (printed 1.10.1959.) on the subject - on the progress of development work in the SKB-203 on the subject of the 1st Directorate - it became known that in accordance with the Decree of the Council of Ministers of the USSR dated September 23, 1958, No.2498-1031, SKB-203 (Sverdlovsk, Yekaterinburg) carried out work on the development of proposals for further work on the design of combat vehicle 2B5. The development of proposals on the design of the 2B5 combat vehicle was carried out on the basis of:

1. Technical Requirements for Development Work issued by SKB-203 NII-24 of March 17, 1959;
2. Drawing of a general view of the projectile with opening stabilizers, issued by NII-147 with letter number 02045 dated 29 April 1959;
3. Drawings of two variants of direct-flow marching engines - attachments to the projectile, sent out by NII-24 in letter No. 02038/156 dated 9 May 1959;
4. Drawings of a general view of the projectile sent out by NII-24 with letter No. 01200/156 of 18 March 1959;
5. Drawing of the shell with rigid plumage sent out by NII-24;

In accordance with these documents, the SKB-203 developed technical documentation for the pre-design of the 2B5 combat vehicle.

In total, the SKB-203 has developed four versions of the combat vehicle.
All developments were conducted for two types of projectiles: for the projectile with retractable stabilisers and for the projectile with rigid plumage. For the projectile with direct-flow engine attachments, the development of the package was not carried out, as it had to be similar to the package for the projectile with rigid plumage.
A total of 4 variants were developed, 3 of which were for the projectile with a swinging plumage.

As a result of the developments, SKB-203 came to the conclusion that it is possible to create a fighting vehicle for the 42-round swing stabiliser projectile and for the 22-round rigid-leaf stabiliser

projectile.
Of the presented options, Pa and Pb options are the most acceptable. These options are similar only for different projectiles (Pa for the projectile with folding stabilizers and Pb for the projectile with rigid plumage).
In these warhead versions, a counterbalance package was provided. In this regard, it was possible to use manual wires of guidance mechanisms. To compensate for the machine's misalignment depending on the terrain, it was introduced that the artillery part of the machine would be horizontally jacked.
Variant III, also designed for firing with retractable stabilizers, was more complex in design and less convenient in operation (more effort on the handle of the artillery unit movement, long time of transfer from camping to combat and back).
In all these variants the artillery unit was mounted on the Ural-375 vehicle, which was the most suitable for this type of combat vehicles.

The SKB-203 also developed a variant of a trailer mounted combat vehicle. The military acceptance considered that this variant was not acceptable due to its low manoeuvrability and cross-country ability.

The following comments were made on the pre-design:

1. In the proposed TTT, paragraph 13 of SKB-203 proposed to limit the angle of vertical guidance in the area of bypassing the cabin to 20 ÷ 50 º. Minimal elevation angle of 20º is not acceptable, as in this case the possibility of maneuvering fire is significantly reduced. In addition, this requirement of SKB-203 is not justified. In versions Pa and Pb it is possible to have a minimum angle of 12º. In this respect it was of interest, also a modification of the Ural-375 with a tarpaulin cabin was developed by the plant, but in this case it would be necessary to solve the issue of the possibility of firing from the cabin.
2. In all variants it is impossible to build a parallel fan by mutual marking.
3. The variants do not have a design of rails. In the version with rigid plumage, a guide rail similar to that for the RZS-115 projectile was adopted, which is not technologically advanced and unacceptable for mass production.
4. Little attention was paid to the mechanical drive in the project. Even at creation of the balanced package, as a result of overrunning of tolerances at large sizes and weights of the package, considerable efforts can be made on the handles of guidance mechanisms. In the project there was given one variant of mechanical drive, but this scheme has already been presented in GAU for ref. № 255ss from 9.5.1958 and in the conclusion of GAU its complexity and necessity of its simplification was noted.
5. SKB-203 suggested reducing the angle of the rear to 30º. The military acceptance considered this to be inappropriate, especially at this design stage.

The conclusions indicated the following:

The military reception considers it possible to create on the basis of Ural-375 a fighting vehicle with 42 guides for a projectile with opening stabilizers and with 22 guides for a projectile with rigid plumage or with attachments of the direct-flow engine.

For further development it was advisable to recommend variants Pa and Pb taking into account the above mentioned remarks.

Below we present data from the annual reports of NII-147 on the development of the future Grad system.

Until 1958 there were no works on jet technology in the subject of research institute №147. In 1958 search works were carried out, the results of which made it possible to establish the expediency of application for manufacturing of powder jet engine casings instead of high-alloy steels of low-carbon steels to hardening in the process of cold plastic deformation.

The use of the cold deformation method will make it possible not only to replace high-alloy deficit steels with low-carbon steel, but also to create the most advanced technological processes acceptable for mass production of jet engine casings.

This direction in the work of the Institute in August 1958 was approved by the Military Industrial Commission of the USSR Council of Ministers and in connection with this plan in 1959 provided for the development, in particular, a 122 mm unguided jet projectile to the field division system

the development, in particular, a 122-mm unguided jet projectile to the field division system.

The 122-mm unguided projectile was subjected to a bench-test of the engine, the design as a whole was developed and the firing tests were carried out in the volume of 67 launches with a ballistic single barrel launcher.

Taking into account the desirability of creating the most powerful system, the projectile was tested with both hard and opening stabilizer, the use of which made it possible to create a combat vehicle with a volley of 39-42 rounds instead of the volley of 30 rounds provided by the TTT. The firing tests carried out showed satisfactory performance of both types of projectiles, ensuring an average range of 23600 m instead of the specified TTT of 20,000 m and a heap rate of fire within the limits specified by the TTT, i.e. W/X is less or equal to 1/200 and W/X is less or equal to 1/130.

The conceptual design of the projectile, developed on the basis of the work performed, was approved by the sections of the Scientific and Technical Councils of the SC SM of the USSR for defense equipment and ANTC of the GAU and recommended for the development of the technical design. The developed design of the projectile provided for the production of all its main parts from low-carbon steel by cold stamping.

In 1960 it was necessary to solve a number of issues related to the choice of the final stabilization and rotation scheme with the solution of thermal protection of the engine, increasing the fragmentation of the combat unit and the replacement of a number of steel parts with plastic ones.

To solve these problems in 1960 it was necessary to manufacture 120 engines and 500 shells and to test them in the volume of 500 launches.

In 1960, for the 122-mm unguided rocket projectile, a bench-top development of the engine without thermal insulation coating was made, the projectile design was developed and tests were carried out in the volume of 420 launches from the ballistic guide mounted on the BM-24 combat vehicle.

The projectile was tested with both rigid and opening plumage. Based on the results of the tests, the design of the projectile with a flip-flop, which made it possible to create a combat vehicle with a volley of 40 rounds instead of 30 rounds provided for by tactical and technical requirements.

The firing tests showed satisfactory performance of the medium range projectile at 21,000 m and a heap of fire:

W/ha = from 1/412 to 1/157 and W/ha = from 1/309 to 1/204.

The developed system "Grad" met the basic requirements of the TTT GAU and had an advantage over the M-14 system: in terms of range - 21 km, instead of 9.5 km, in terms of number of barrels - 40 instead of 16, the weight of the explosive in one projectile - 6.8 kg, instead of 4.2 kg of useful fragments - 3070 instead of 1800.

The projectile was designed to produce main parts from low-carbon steel by cold stamping, plastics and light alloys.

The technical design of the projectile, developed on the basis of experimental works, was recommended for manufacturing of the factory batch.

The developed technical design of the combat vehicle also met the main tactical and technical requirements and was recommended for manufacturing of a prototype. A prototype that had undergone acceptance testing could be recommended for factory testing.

In 1961, it was necessary to carry out factory tests of the Grad system and to manufacture a prototype batch of projectiles and two combat vehicles for range testing: to carry out this work, 1300 projectiles and 450 engines would need to be manufactured during the 9 months of 1961.

In 1960, the Institute carried out research on the possibilities of using plastics materials for engine parts for "Grad" projectiles.

Directions of further works on mechanization and automation of manufacture and creation of the equipment: on development of means of mechanization and the non-standard equipment in connection with statement on manufacture of uncontrollable jet projectiles of system " Grad ".

In connection with the successful completion of structural and technological development of unguided rockets system "Grad", there were significant works to develop means of mechanization and non-standard equipment, the creation of which is necessary in connection with the

and non-standard equipment, the creation of which is necessary in connection with the forthcoming placement of these shells in production.

The main direction of work was the development of anti-corrosion and interoperation coatings for parts and products of "Grad";

The following work was done in these main areas:

At manufacturing of details for "Grad" products - the method of deep drawing revealed the necessity of correction of technological process of interoperation phosphating of semi-finished products in view of design and technological features of details. In the corrected technological process it has been provided jet washing of half-finished products, time of phosphating has been corrected, and also the additive of an oxidizer has been regulated that has allowed to receive the interoperational covering providing hooding process.

Last year paint and zinc-phosphate coatings were studied to protect Grad parts from corrosion. According to the results of the research works, zinc-phosphate coating was accepted for manufacturing of the factory batch of "Grad" products".

In 1960 the Institute produced a complex development of one projectile of "Grad" system.

In 1961 the factory development of the "Grad" divisional field rocket system consisting of 122-mm unmanned 3OF10 projectile and 2B-5 mobile launcher was finished.

The tested system "Grad" meets all main tactical and technical requirements of GRAU.

The heap of combat at single firing at the maximum range is equal: in the range of Vd/x = 1/280, in the direction of Vb = 1/161. At volley shooting the heap of combat was equal: in the range of Vd/x = 1/204, in the direction of Vb/x = 1/165.

The 3OF10 round was much more effective than the M14OF round.

In 1962 the testing of the Grad division field rocket system consisting of 122-mm unguided 9M22 projectile and 2B-5 mobile launcher was conducted.

The proven "Grad" system meets the tactical and technical requirements of the GRAU.

Having considered the results of the "Grad" system testing, the State Committee of the USSR Council of Ministers for Defence Equipment recommended the "Grad" system for adoption by the Soviet Army.

The conclusion on the Grad system testing approved by the Commander of the Missile Forces and Artillery Chief Marshal of Artillery T. Varentsov also recommended the "Grad" system for adoption in service of the Soviet Army.

The "Grad" reactive system is a powerful new means of suppressing and destroying enemy manpower and field defense facilities.

The system has effective action on various targets, significant volley power (for 20 seconds 40 rounds with total weight of BB 272 kg), range of 20 km and high maneuverability of fire and march.

The "Grad" system as a whole is much more effective than the standard BM-14-17 system. Thus, to solve the same task with 9M22 shells, 2 combat vehicles (4.5 volleys) are required, and with M-14OF shells 7 combat vehicles (6.3 volleys) are required.

The design of the "Grad" projectile system has been developed taking into account the possibility of manufacturing the main parts by cold stamping of low-carbon steel. Some parts of the projectile are made of plastic materials.

In 1962 NII-147 carried out work on the jet projectile "Lake" in the equipment with the substance "R-35" and the substance "R-33" with a non-contact fuse (theme KRZ-122-61).

The "Lake" projectile had a special head with a radio detonator and is being developed on the basis of the "Grad" projectile.

In 1962 it was tested on the stages of conceptual and technical projects.

Developed at the stage of the technical project, the special Jet Skinjet projectile with a non-contact fuse meets the main tactical and technical requirements of the GRAU".

During the development of the product at the stages of conceptual and technical designs the optimal ratio of ammunition components in the equipment with formulas "R-33" and "R-35" at an average height (5 m) of the specified TTT range of heights (1-12 m) fuse triggering with performance tests of 20 products was chosen;

- The fragment of the side and bottom filling product was determined with the testing of 12 products;
- ballistic characteristics (X, Vb, Vd) were determined with testing of 100 products;
- the location of the filler glasses was chosen;
- Tests on the processability of equipment 10 ed;
- Accelerated tightness tests were carried out in the 20th ed.

As a result of tests it was received: the maximum range of firing at normal temperature 17972 m (for projectile 9M22 X≈20700 m).

Dispersion by single projectiles from the war machine to the maximum range in the entire temperature range from -40° to +50° in the range and direction no more than that of the 9M22 fragmentation projectile.

The efficiency of 9M23 in the "R-33" projectile when detonated at the height of 5 m above the ground is 3 times higher than that of the MS-14 fragmentation special projectile in the "R-35" projectile when detonated on the ground.

The effective use of the projectile in the R-33 equipment was ensured when the non-contact fuse was triggered at the altitudes in the range of 5-30 m.

The optimal range of heights of ruptures of 9M23 projectiles in the "R-35", providing an increase in efficiency in comparison with ruptures on the ground, was 4-6 m.

In case of rupture at the height of 8 m and more the projectile efficiency is even lower than in case of rupture on the ground.

Taking into account the impossibility to create a non-contact fuse with the range of detonation heights of 4-6 m and the fact that in case of explosions at the height of 8 m and more the effectiveness of the projectile in the "P-35" is lower than in case of an explosion on the ground, it is not reasonable to create a projectile in the "P-35" with a non-contact fuse.

In 1963, at the factory development stage it was necessary to carry out modification of the whole projectile and its elements in the direction:

- ensuring the operational altitude of the non-contact fuse in the range of 5-30 m, which provides high efficiency of the projectile in the equipment with the substance "P-33".
- wider verification of the optimal ratio of weights of BB and special substance "R-33";
- checking the possibility of firing at a range of 4-5 km, based on the condition of ensuring the safety of their troops;
- development of the technology of lacquer coating instead of varnish №67 on the inner surface of the head part;
- Checking the effectiveness of the projectile in the R-35 with a 9Z210 (from a Grad projectile) impact fuse.

In 1963, the Unmanned Rocket Launchers "Lake" were put on factory and field tests. Work on the rocket projectile "Lake" in the equipment of the substance "R-35" and the substance "R-33" with a non-contact fuse /theme KRZ-122-61 / continued.

The "Lake" projectile was developed on the basis of the "Grad" projectile and differed from it by a special head part.

The head part /hull and glass/ were made of low-carbon steel by deep-drawing method, the connection between the body and glass was made by automatic welding under a layer of flux.

In 1963, this projectile was tested at the factory testing stages and a batch was produced for landfill testing. In accordance with the decision of GRAU MO, GKOT and UNHV MO two versions of the projectile were tested:

- a projectile in R-33 equipment with a non-contact fuse;

- projectile in the outfit with the substance "R-35" with an impact fuse.

At the factory development stage the work was carried out in the following directions:

a/ creation of a unified design of the head end both for the variant with the substance "R-33" and for the variant with the substance "R-35";

b/ a broader study of the ratio of weights of BB and the substance in order to establish the optimal weight ratio for both substances;

c/ a final determination of the optimum fusing heights to ensure the highest effectiveness of the projectile at the target over the entire range;

d/ working on the tightness of the filler point angle;

e/ refining of the lacquer coating technology on the inner surface of the head end.

Taking into account recommendations of GKOT, GRAU MO and UNHV MO, a factory batch of 300 projectiles was manufactured and tested.

The factory tests showed that the "Lake" projectile meets the main tactical and technical requirements of GRAU MO No 0010044 and No 0010091. At the same time, the average experimental range of the projectiles with non-contact fuses in the temperature range from -40° to +50° C is 18803 m with the fuses of shock action at normal temperature - 20217m;

average dispersion characteristics when firing projectiles with non-contact fuses from a war machine at the maximum range in the whole temperature range from -40° to +50°C is 1/342 in the WD/Hop direction and 1/165 in the WD/Hop direction, which is not worse than that of the Grad fragmentation projectile; with warhead fuses, the maximum range at normal temperature is 1/249 in the direction of impact from the warhead and 1/203 in the direction of impact from the warhead;

efficiency of the projectile in the equipment with the substance "P-33" with the fuse of non-contact action at the optimal height of the fuse / 20 times higher than the efficiency of the standard projectile MS-14 in the equipment with the substance "P-35" at the ground burst;

the effectiveness of the projectile in the P-35 with an impact fuse is 1.2¸1.4 times higher than the effectiveness of the MS-14 projectile in the same equipment;

the head part of the "Lake" projectile is hermetic;

Non-contact trigger heights range from 0.5 to 30 m, with 85% of the fuses detonated at heights between 3 and 25 m. This range of fuse heights ensures high projectile effectiveness at the target.

Taking into account positive results of the factory tests, the projectile in the equipment with the substance "R-33" with a non-contact fuse and the projectile in the equipment with the substance "R-35" with an impact fuse by the decision of the GKOT and GRAU MO are recommended for polygon-engineering tests.

For testing on the range according to the agreed technical documentation 600 shells were manufactured and delivered to the customer's representative.

In 1964, projectile testing was to be carried out on the target range.

In 1963 NII-147 carried out research work on creation of progressive technology and tooling for production of "Grad" system rocket projectile /theme TT11-667-63/.

This work provided for the development of technology ensuring minimum cost of RS production due to the reduction of materials consumption and labor costs when equipping the production with high-performance equipment and fixtures.

In accordance with this topic, a considerable amount of work was carried out in 1963.

Technological processes were developed and experimental works were carried out to obtain new types of blanks: head shells without boring, cone skeletons from pipes, fairings (without milling grooves), brake rings and stabilizer rings produced by forging method.

Improvement of technical processes of the specified details will allow to reduce the expense of metal on one projectile on 26 kg, the factor of use of metal will make 76 % against 43 % according to settlement data of technical process of 1962.

The technological process of thermal insulating coating application on the machine tool CO-2 of the NII-147 design with the use of HFF, which reduces the time of working off a set of pipes by about 2 times and improves the quality of the coating, has been worked out and implemented.

Designed special machines and control devices recommended for testing and control of the product "Grad" / two-sided lathe semi-automatic model STA-1 for the processing of pipes, the aggregate machine model AC-1 for processing the lid and the frame of the lid, installation for coiling of pipes, model US-1, multi-dimensional control device PMK-16 and others/, picked up the type of standard press and metal-cutting /automatic and semi-automatic machines/ equipment and developed technical processes for the recommended equipment. When introducing the newly designed and recommended standard equipment into production, the productivity of machining should increase by about 8-10 times against the existing equipment.

With the improvements, it is planned to reduce the labour intensity of the Grad projectile by almost 2.5 times.

Specialists of the Institute and the enterprise of p/a 43 have developed a complex plan of the organization of production and reduction of labor intensity in the manufacture of shell "Grad".

In 1963 NII-147 also rendered technical assistance to the enterprise of p/o 43.

In 1963 works on statement on a batch production of a shell of system "Grad" were carried out. For realization of technical management the introduction group from experts of institute has been created. Together with workers of factory processing of technical processes with reference to the equipment of factory was carried out.

The Institute has designed 15 items of special equipment, eleven of which were assembled and put into operation. Testing of technological processes in the manufacture of parts and preparation of production for the production of shells.

However, the 43rd plant started to prepare and deploy production only in the second half of 1963.

Along with technical assistance provided by specialists, 1000 head and tail pipe blanks, 250 fairing blanks, 40 sets of plastic and other parts of 8 names, 2000 blanks of blades and heat treatment of 250 sets of cones were manufactured and handed over to the plant on the pilot base of the Institute.

Zinc plating of pipes with application of thermal insulation coatings was carried out, 5 inductors for machine tools with application of HFF, a device for thickness control of thermal insulation coatings and a device for checking electrical resistance of projectile targets were manufactured. 17 bench motors for projectile demonstration were manufactured.

In 1963, the company 43 manufactured and delivered to the customer 12 full-scale, 13 stand and 100 Grad training rounds.

Further we give the data of the State Archive Institution of Tula Region "State Archive" (Russia, Tula).

Report on execution of the research and development plan for 1962

Investigation of anticorrosive coatings on "Grad" projectile parts depending on conditions for the duration of storage.

…

2) Manufacturing of prototypes of coated parts and bookmarked for long-term storage.

(a) Manufacture of pilot batches of parts:

steel parts galvanized from acid electrolyte and phosphated from cold solution, galvanized from acid electrolyte and passivated, galvanized from cyanide electrolyte with the following passivation or phosphatization, galvanized from acid electrolyte with the following phosphatization and coating on the inner surface with B-58 coating, phosphatized painted inside with lacquer 67, gray blue paint outside.

b/aluminum anodized with bichromate impregnation. Parts with the above coatings are placed in a

closed warehouse and canopy for long-term storage.

Rendering technical assistance to the plant in preparation for production of products for the system "Grad".

All the necessary documentation for the manufacture of products to the system "Grad" is sent to the plant № 176, GSPI-4, Tula Combine Plant, Giprotractorselkhozmash all the necessary for the manufacture of products to the system "Grad" technical documentation: the process of mechanical and press processing, anti-corrosion coating, plastic parts manufacturing, thermal protection coatings, instructions, drawings of molds, devices, instrumentation tools.

Together with the plant №176 there was made a calculation of the need of the equipment quantity for manufacturing of the products; there was developed the layout of the "Zh" case with placement of the equipment necessary for manufacturing of the products; there was made the schedule of designing of the non-standard equipment with indication of the terms of manufacturing and executors; there was developed the technical task for designing of the machines for tube, head part, cones coiling;

The terms of reference for the design of a machine tool for cleaning the outer surface of pipes is being developed; and others.

Experimental design works. 1962.

KRZ-122-61. Chemical reactive projectile in the equipment "P-35" and substance "60" with a non-contact fuse on the basis of the projectile to the system "Grad" - ("Lake").

1. 1. Development of a conceptual design, a projectile confirmed by tests. Are given out TTZ to the adjacent organizations. Product drawings of two variants are developed: the head part with a lateral arrangement of a filler point and the head part with a bottom arrangement of a filler point.

Fuel plant 91.

Grad" projectile

Additional work for polygon-arms testing based on the decision of the joint meeting of the section of the Technical Council of GKOT and GRAU.

In accordance with the decision of GKOT and GAU for polygon tests in 1962, 210 additional shells were manufactured. In June landfill tests with satisfactory results were completed.

By the order of GKOT No. 416 of 11.7.62 and the conclusion of GRAU No. A/715490 of 25.IX.62, the Grad rocket system was recommended for adoption by the Soviet Army. For the testing of the 2B5 in September of this year, 50 rounds were manufactured, which were sent to the 33491 hour.

In accordance with the plan /ex. № 11-3490 of 15.X.62 y./ approved by the GKOT and GRAU modification of the strength of stickers armored gunpowder charge draughts with the reliability of centering gunpowder charge draughts. Powder charge stickers were tested with positive results.

Report on execution of the research and development plan for Q1 1963.

engineering research

Selection and analysis of materials of domestic press, metal-cutting, chemical and thermal equipment as applied to Grad rocket projectile system.

The materials were selected and the analysis of the domestic equipment for press, metal cutting, chemical and thermal treatment and welding, applied to RS "Grad".

OKP .

Jet chemical projectile in the equipment "P-35" and the substance "C-60" with a non-contact fuse based on the projectile to the system "Grad Lake".

Manufacturing of prototypes of projectiles for factory tests and carrying out factory tests.

Manufacturing of 150 pcs. of shells for pre-factory development of non-contact fuse. The program of tests of the factory batch of shells is developed. Manufactured reactive charges.

The factory batch of 350 shells and the batch of explosive charges in the amount of 400 sets were

put into production.

On the theme "Jack" - not completed factory tests (term II sq. 63 g.). Manufacturing and delivery of shells is delayed due to overload of the Institute's production base with additional works.

The report on performance of the plan of research and development and design works for II quarter 1963.

Jet chemical projectile in the equipment "P-35" and the substance "C-60" with a non-contact fuse based on the projectile to the system "Grad" - "Lake.

Manufacturing of prototypes of projectiles for factory tests and carrying out factory tests.

Manufacturing of 150 shells for pre-factory testing of the non-contact fuse. They were tested in the amount of 50 launches. The program of tests of the factory batch is developed. Manufactured 200 shells for the factory batch.

Ballistic tests and efficiency tests are being carried out. The factory tests are not completed due to the delay in shell manufacture and delivery due to the overload of the Institute's production base with additional works.

Report on execution of the research and development plan for the III quarter of 1963.

Jet chemical projectile in the equipment "P-35" and the substance "C-60" with a non-contact fuse based on the projectile to the system "Grad Lake".

Product 9M23

Manufacturing of prototypes of projectiles for factory tests and carrying out factory tests.

Manufacturing of a pilot batch of shells for factory tests in the amount of 250 pcs. Tests for projectile efficiency in w/h 61469 with positive results /act w/h 61469 from 13/IX-63 No. 000011221 were conducted.

Tests of radio detonators and ballistic tests of shells in w/h ¹27374. The heap of combat was obtained by firing at the maximum range with a non-contact fuse.

X = 18.34, W/X = 1/396,

W/X = 1/152, with impact fuse X = 20.2 km,

W/X = 1/249, W/X = 1/203

/protocol of the joint commission at p.m. № 27374 from 19/UIII-63 № 001172/.

Tests of head parts for shattering and shattering effect at a.m. № 33491 were conducted. The results are positive. The head units were tested for tightness at the plant № 91 of the Nizhne-Volzhskiy SNC. The results are positive /telegram of the plant ¹ 91 from 21/IX-63 ¹3444/.

Based on the results of the factory testing made a technical report and sent to the GKOT and / h ¹ 64176 30/IX-63 for the outgame. ¹ 05019.

Taking into account the positive results of the factory development, by the decision of GKOT and r/h ¹ 64176 from 10/IX-63 /isch. ¹ 6-4821/ the shell "Leika" is recommended for range and armor tests. Due to the increase in the number of specimens supplied for testing at the range up to 600 pieces, the term of completion of these works was set in 1U quarter 1963.

On this issue also see the galleries on our website:

"Coordination of tactical and technical requirements for the development work "Grad Division Field Jet System from the Special Design Bureau № 203 (SKB-203) (Sverdlovsk)";

"Preliminary design of 122 mm of the unguided Grad rocket system. /Report of Deputy Director of NII-147 on scientific part, Comrade Ganicheva A.N./".

"On comments to TTT No. 007738 of the Main Artillery Department (GAU) on "Grad" system.

Linked materials:

M-21 Field rocket system

- Русский

Contact

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